

Development of a high luminosity flat flame burner

Val Smirnov* and Chet Allen* demonstrate how the design of a high luminosity burner can significantly reduce fuel consumption and NOx emissions.

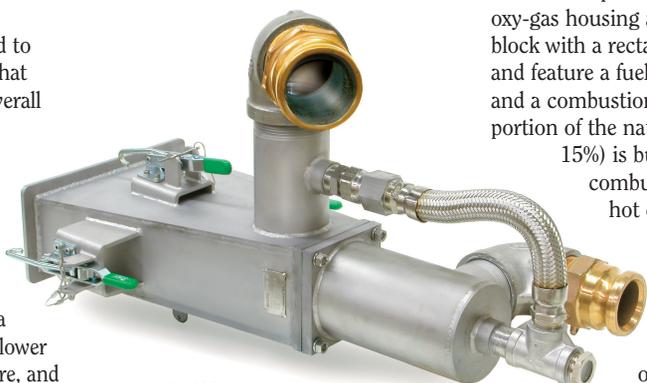
Recent developments in oxy-fuel combustion technology show significant improvement in thermal efficiency of glass melting furnaces. Earlier generation air-gas and oxy-gas flames are a low luminosity burning jet, which forms non-uniform temperature and heat flux distributions. The flame appearance in the hot furnace is mostly semi-transparent, leading to poor radiant heat transfer to the load and decreased thermal efficiency. Non-uniform temperature profiles lead to formation of hot spots that reduce refractory and overall furnace life.

Burner design

To overcome the limitations of current oxy-fuel technology, a new burner design was introduced which offers a more luminous flame, a lower average flame temperature, and more uniform temperature and heat flux profiles. Built upon the oxy-fuel flat flame burner, the PrimeFire 400 high luminosity burner (PF400) is designed to significantly reduce fuel consumption and NOx emissions over comparable burners, while fitting into existing control schemes. It increases thermal

efficiency and decreases NOx formation by increasing the radiant heat transfer to the load.

Combustion researchers have demonstrated that gas preheating and soot addition to the flames leads to higher radiation heat transfer and increased flame luminosity. In this new combustion system, soot precursors are formed by injecting a small amount of oxygen into the gas stream prior to the main combustion process, so the gas

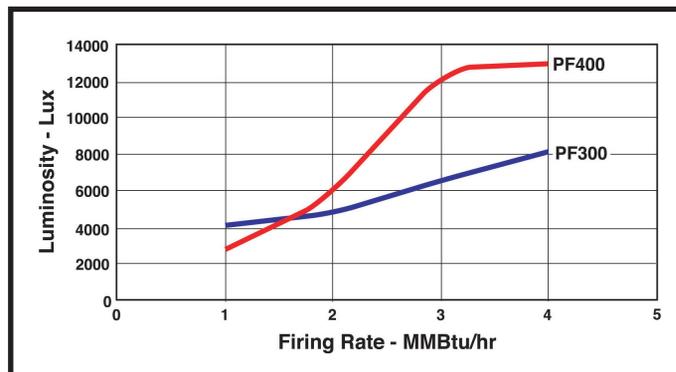


▲ PF400 burner.

begins to 'crack', releasing greater amounts of carbon.

Subsequently, carbon soot particles are formed and burned in the main combustion process, increasing flame luminosity by 20-30 per cent over comparable flat flame burners. This leads to higher radiant heat flux to the load, while radiative cooling of the flame reduces the flame temperature. As a result, heat transfer uniformity is increased and NOx emission is reduced by up to 18 per cent. Flame geometry and flame length are also comparable with existing flat flame burners, so no changes in furnace design are needed.

▲ PF400 flame shown in lab testing.



▲ Fig 1.

PF400 burners have firing ranges of 0.5-2, 1-4, 2-8, 6-20 MM Btu/hr to satisfy all glass furnace firing rates; all models are capable of 4:1 turndown and can be fired using natural gas or fuel oil. They consist of a pre-combustor, main oxy-gas housing and refractory block with a rectangular passage, and feature a fuel preheating zone and a combustion (flame) zone. A portion of the natural gas (up to 15%) is burned in the pre-combustor to generate hot combustion gases. The remaining natural gas is preheated in the absence of oxygen by mixing with the pre-combustor hot combustion gases. This provides the time and temperature needed for hydrocarbon soot precursors to be formed.

Operation and application

The hot gas mixture containing soot precursors and soot nuclei is burned in a flame in which oxygen introduction is controlled to create fuel-rich and fuel-lean combustion zones. Oxygen and preheated natural gas pass through the same rectangular channel in the refractory block. Oxygen surrounds the natural gas flow, keeping the block relatively cool while picking up heat and beginning the combustion process. Temperature and residence time in the fuel-rich combustion zone are controlled to provide sufficient time for soot to form in the flame and for the desired flat flame geometry to develop.

Additional oxygen surrounding the flame creates the fuel-lean combustion zone. Soot particles are formed in the fuel-rich flame zone and radiate to produce a highly luminous flame. All the soot then burns out in the fuel-lean zone of the flame. To maximise thermal efficiency and heat transfer into the load, the entire flat flame envelope is located in the furnace over the glass surface.

Testing a 1-4 MM Btu/hr PF400 burner in a test furnace showed that this burner formed a much more luminous flame than the standard Eclipse PF300 burner. The luminosity was measured like a source of light using a light meter. Fig 1 shows that the luminosity is 1.5-2 times higher than that of a PF300 burner and increases with the burner's capacity.

This higher luminosity leads to increased flame-to-load heat transfer and thus potential fuel savings. Total heat transferred is by convection and radiation, so only testing in a glass furnace will provide the actual data.

The PF400 1-4, 2-8 and 6-20 MM Btu/hr burners were installed in an insulating glass fibre furnace and a float glass furnace in 2002. The burner flames had a flat and very luminous appearance in the furnace, with good glass surface coverage. GTI/Eclipse testing on the float furnace confirmed the fuel consumption and NOx emission reductions. After about 18 months of operation with PF400 burners installed, both glass manufacturers confirm the furnace thermal efficiency increase. **G**

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